



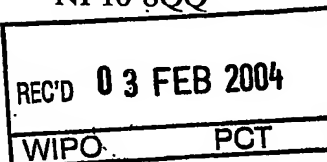
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Newport  
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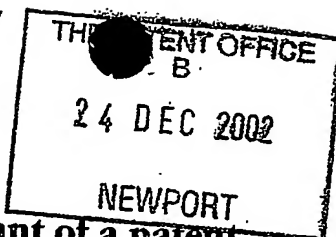
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Dated 23 January 2004

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Patent 1977  
(Rule 16)



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P01/7700 0.00-0230072.1

# Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road  
Newport  
South Wales  
NP10 8QQ

1. Your reference

528

2. Patent application number

(The Patent Office will fill in this part)

0230072.1

24 DEC 2002

3. Full name, address and postcode of the or of each applicant (underline all surnames)

ELAM-T LIMITED  
103 BOROUGH ROAD  
LONDON  
SE1 OAA

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

08105280001

4. Title of the invention

ELECTROLUMINESCENT MATERIALS AND DEVICES

5. Name of your agent (if you have one)

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

COHEN, ALAN NICOL  
2 GROVE PLACE  
TATSFIELD  
Nr. WESTERHAM  
KENT  
TN16 2BB

Patents ADP number (if you know it)

0696355700

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number  
(if you know it)

Date of filing  
(day / month / year)

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing  
(day / month / year)

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

YES

- a) any applicant named in part 3 is not an inventor, or
  - b) there is an inventor who is not named as an applicant, or
  - c) any named applicant is a corporate body.
- See note (d))

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form

Description

16

Claim(s)

4

Abstract

1

Drawing(s)

13 + 13

Ph.

10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77)

Request for preliminary examination and search (Patents Form 9/77)

Request for substantive examination (Patents Form 10/77)

Any other documents

(please specify)

11.

I/We request the grant of a patent on the basis of this application.

Signature

*[Signature]*

Date

23/12/02

12. Name and daytime telephone number of person to contact in the United Kingdom:

A. N. Cohen

01959 577172

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Notes

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- If you have answered 'Yes' Patents Form 7/77 will need to be filed.
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- For details of the fee and ways to pay please contact the Patent Office.

## Electroluminescent Materials and Devices

The present invention relates to electroluminescent materials and to electroluminescent devices.

5

Materials which emit light when an electric current is passed through them are well known and used in a wide range of display applications. Liquid crystal devices and devices which are based on inorganic semiconductor systems are widely used, however these suffer from the disadvantages of high energy consumption, high cost  
10 of manufacture, low quantum efficiency and the inability to make flat panel displays.

Organic polymers have been proposed as useful in electroluminescent devices, but it is not possible to obtain pure colours, they are expensive to make and have a relatively low efficiency.

15

Another compound which has been proposed is aluminium quinolate, but this requires dopants to be used to obtain a range of colours and has a relatively low efficiency.

20

Patent application WO98/58037 describes a range of lanthanide complexes which can be used in electroluminescent devices which have improved properties and give better results. Patent Applications PCT/GB98/01773, PCT/GB99/03619, PCT/GB99/04030, PCT/GB99/04024, PCT/GB99/04028, PCT/GB00/00268 describe electroluminescent complexes, structures and devices using rare earth chelates.

25

US Patent 5128587 discloses an electroluminescent device which consists of an organometallic complex of rare earth elements of the lanthanide series sandwiched between a transparent electrode of high work function and a second electrode of low work function with a hole conducting layer interposed between the

electroluminescent layer and the transparent high work function electrode and an electron conducting layer interposed between the electroluminescent layer and the electron injecting low work function anode. The hole conducting layer and the electron conducting layer are required to improve the working and the efficiency of the device. The hole transporting layer serves to transport holes and to block the electrons, thus preventing electrons from moving into the electrode without recombining with holes. The recombination of carriers therefore mainly takes place in the emitter layer.

10 We have now invented electroluminescent compounds and devices incorporating them.

According to the invention there is provided electroluminescent compounds of formula  $M(L)_n$  and  $MO(L)_{n-2}$  where M is a metal in a valency state n of greater than 3 and L is an organic ligand, the ligands L can be the same or different e.g.  $M(L_1)(L_2)(L_3)(L_4)\dots$  or  $MO(L_1)(L_2)\dots$

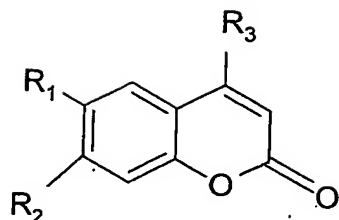
Preferably the metal M is a transition metal such as titanium, zirconium or hafnium in the four valency state or vanadium, niobium or tantalum in the five valency state.

20 Preferably the electroluminescent compound is doped with a dopant preferably in an amount of 5 to 15% of the doped mixture.

Dopants which can be used include diphenylacridine, coumarins, perylene and their derivatives.

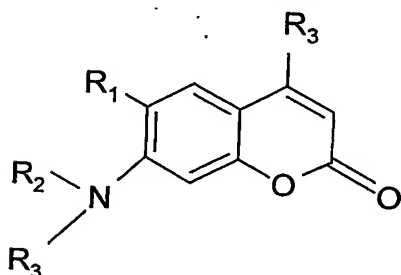
25

The preferred dopants are coumarins such as those of formula



(A)

- 5 where  $R_1$ ,  $R_2$ , and  $R_3$  are hydrogen or an alkyl group such as a methyl or ethyl group, amino and substituted amino groups e.g.

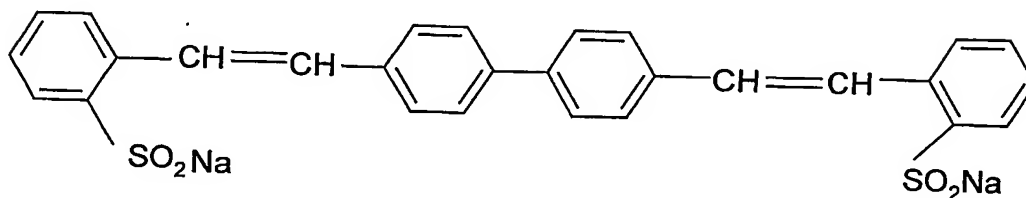


(B)

where  $R_3$  is hydrogen or alkyl group such as a methyl or ethyl group,

- 10 Examples of coumarins are given in figs. 9 and 10 of the drawings

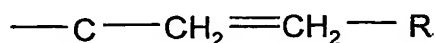
Other dopants include salts of bis benzene sulphonic acid such as



(C)

15 and perylene and perylene derivatives and dopants of the formulae of figs. 11 to 13 of the drawings where  $R_1$ ,  $R_2$ ,  $R_3$  and  $R_4$  are R,  $R_1$ ,  $R_2$ ,  $R_3$  and  $R_4$  can be the same or different and are selected from hydrogen, hydrocarbyl groups, substituted and unsubstituted aromatic, heterocyclic and polycyclic ring structures, fluorocarbons

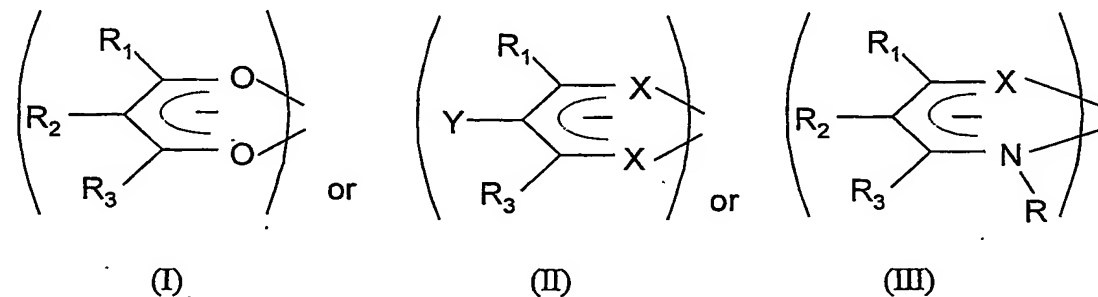
such as trifluoromethyl groups, halogens such as fluorine or thiophenyl groups;  $R$ ,  $R_1$ ,  $R_2$ ,  $R_3$  and  $R_4$  can also form substituted and unsubstituted fused aromatic, heterocyclic and polycyclic ring structures and can be copolymerisable with a monomer e.g. styrene.  $R$ ,  $R_1$ ,  $R_2$ ,  $R_3$  and  $R_4$  can also be unsaturated alkylene groups such as vinyl groups or groups



where  $R$  is as above.

The formulae of examples of the complexes are shown in fig. 1a and fig. 1b of the accompanying drawings where  $M$  is titanium, zirconium or hafnium in the four valency state and  $(L_1)$ ,  $(L_2)$ ,  $(L_3)$  and  $(L_4)$  can be the same or different and can form fused cyclic, heterocyclic, aromatic or substituted aromatic rings or fig 1c and 1d where  $M$  is vanadium, niobium or tantalum in the five valency state and  $(L_1)$ ,  $(L_2)$ ,  $(L_3)$ ,  $(L_4)$  and  $(L_5)$  can be the same or different and can form fused cyclic, heterocyclic, aromatic or substituted aromatic rings.

Other preferred ligands  $L$  are quinolate, porphyrin, porphines, pyrazalones, such as 5,10,15,20-tetra(4-pyridyl) 21H,23H-porphine 5,10,15,20-tetra(p-tolyl) 21H,23H-porphine and meso- tetraphenyl porphine and  $\beta$  diketones such as dibenzoyl methane and ligands of formula

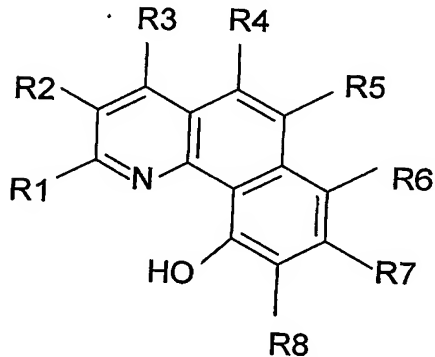


where  $R_1$ ,  $R_2$  and  $R_3$  can be the same or different and are selected from hydrogen, and substituted and unsubstituted hydrocarbyl groups such as substituted and unsubstituted aliphatic groups, substituted and unsubstituted aromatic, heterocyclic and polycyclic ring structures, fluorocarbons such as trifluoromethyl groups, halogens such as fluorine or thiophenyl groups;  $R_1$ ,  $R_2$  and  $R_3$  can also form

substituted and unsubstituted fused aromatic, heterocyclic and polycyclic ring structures and can be copolymerisable with a monomer e.g. styrene. X is Se, S or O, Y can be hydrogen, substituted or unsubstituted hydrocarbyl groups, such as substituted and unsubstituted aromatic, heterocyclic and polycyclic ring structures, fluorine, fluorocarbons such as trifluoromethyl groups, halogens such as fluorine or thiophenyl groups or nitrile.

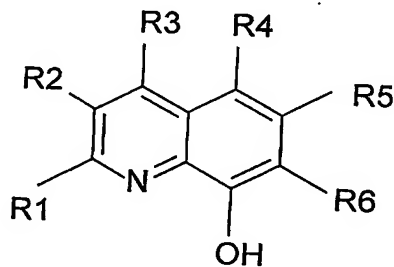
Examples of  $R_1$  and/or  $R_2$  and/or  $R_3$  include aliphatic, aromatic and heterocyclic alkoxy, aryloxy and carboxy groups, substituted and substituted phenyl, fluorophenyl, biphenyl, phenanthrene, anthracene, naphthyl and fluorene groups alkyl groups such as t-butyl, heterocyclic groups such as carbazole.

In dibenzoyl methane in (I)  $R_1$  and  $R_3$  are phenyl groups and  $R_2$  is hydrogen. Other ligands L can be



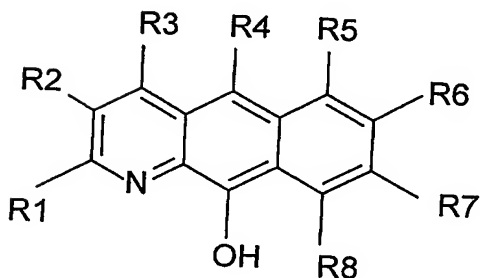
(IIIa)

or



(IIIb)

or

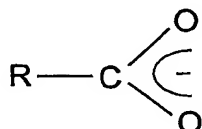


(IIIc)



where the group R can be the same or different and are selected from hydrogen, and substituted and unsubstituted hydrocarbyl groups such as substituted and unsubstituted aliphatic groups, substituted and unsubstituted aromatic, heterocyclic and polycyclic ring structures, fluorocarbons such as trifluoromethyl groups, halogens such as fluorine or thiophenyl groups;  $R_1$ ,  $R_2$  and  $R_3$  can also form substituted and unsubstituted fused aromatic, heterocyclic and polycyclic ring structures and can be copolymerisable with a monomer e.g. styrene.

Some of the different groups L may also be the same or different charged groups such as carboxylate groups so that the group  $L_1$  can be as defined above and the groups  $L_2$ ,  $L_3$ ... can be charged groups such as



(IV)

where R is  $R_1$  as defined above or the groups  $L_1$ ,  $L_2$  can be as defined above and  $L_3$ ... etc. are other charged groups.

$R_1$ ,  $R_2$  and  $R_3$  can also be

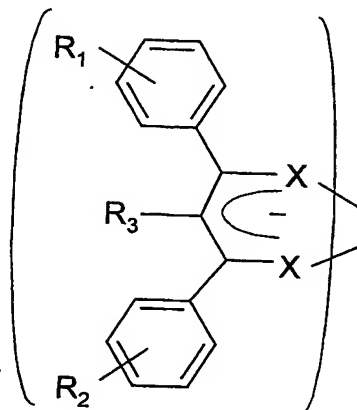


where X is O, S, Se or NH.

(V)

A preferred moiety  $R_1$  is trifluoromethyl  $CF_3$  and examples of such diketones are, benzoyltrifluoroacetone, p-chlorobenzoyltrifluoroacetone, p-bromotrifluoroacetone, p-phenyltrifluoroacetone, 1-naphthoyltrifluoroacetone, 2-naphthoyltrifluoroacetone, 2-phenanthroyltrifluoroacetone, 3-phenanthroyltrifluoroacetone, 9-anthroyltrifluoroacetone, cinnamoyltrifluoroacetone, and 2-thenoyltrifluoroacetone.

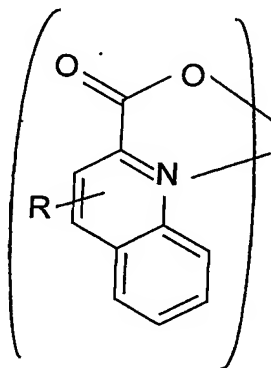
The different groups L may be the same or different ligands of formulae



(VI)

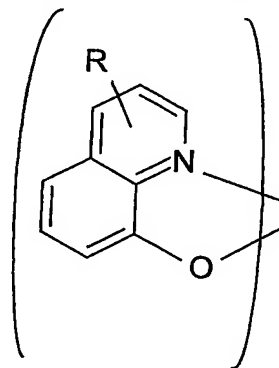
where X is O, S, or Se and  $R_1$ ,  $R_2$  and  $R_3$  are as above

The different groups L may be the same or different quinolate derivatives such as



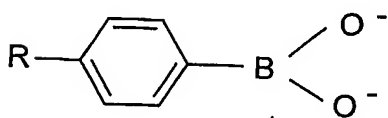
(VII)

or



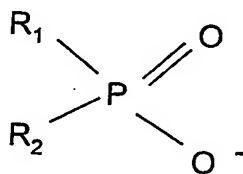
(VIII)

where R is hydrocarbyl, aliphatic, aromatic or heterocyclic carboxy, aryloxy, hydroxy or alkoxy e.g. the 8 hydroxy quinolate derivatives or



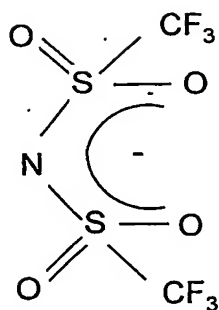
(IX)

or



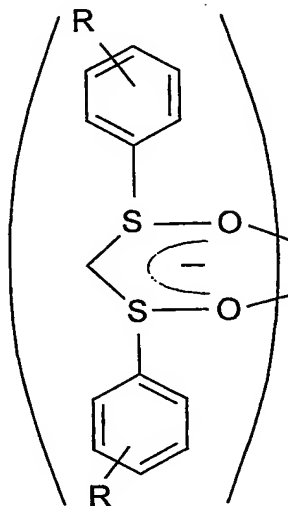
(X)

where R, R<sub>1</sub>, and R<sub>2</sub> are as above or are H or F e.g. R<sub>1</sub> and R<sub>2</sub> are alkyl or alkoxy groups



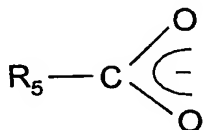
(XI)

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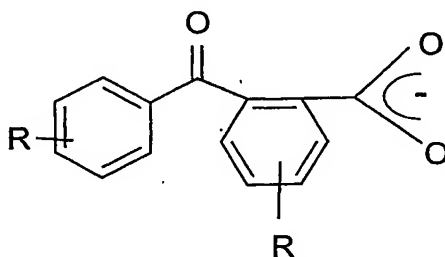
(XII)

- 5 As stated above the different groups L may also be the same or different carboxylate groups e.g.



(XIII)

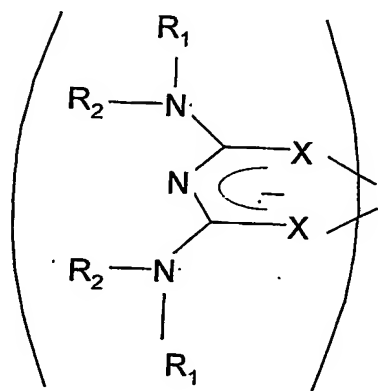
- 10 where R<sub>5</sub> is a substituted or unsubstituted aromatic, polycyclic or heterocyclic ring a polypyridyl group, R<sub>5</sub> can also be a 2-ethyl hexyl group so L<sub>n</sub> is 2-ethylhexanoate or R<sub>5</sub> can be a chair structure so that L<sub>n</sub> is 2-acetyl cyclohexanoate or L<sub>a</sub> can be



(XIV)

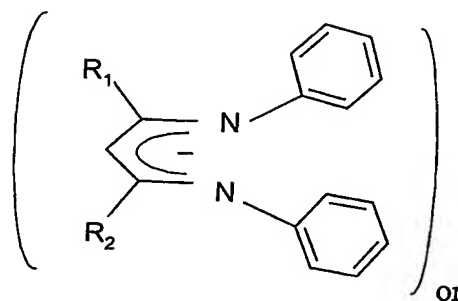
where R is as above e.g. alkyl, allenyl, amino or a fused ring such as a cyclic or polycyclic ring.

5 The different groups L may also be



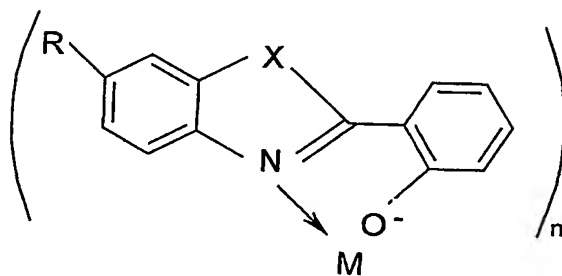
(XV)

or



(XVI)

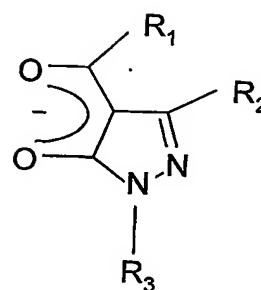
or



where X is O, S or Se

(XVII)

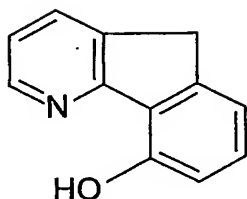
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(XVIII)

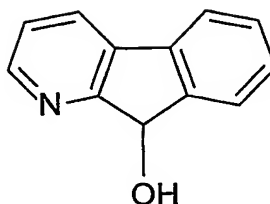
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Where R, R<sub>1</sub> and R<sub>2</sub> are as above.

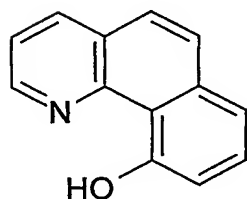


(XVIIIb)

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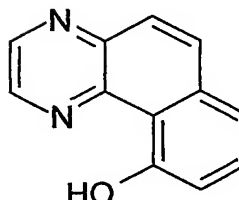


(XVIIc)



(XVIIId)

or



(XVIIe)

5

The invention also provides an electroluminescent device which comprises (i) a first electrode, (ii) a layer of a electroluminescent compound as described above and (iii) a second electrode.

10

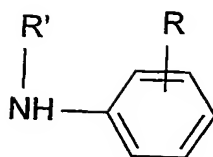
The first electrode can function as the cathode and the second electrode can function as the anode and preferably there is a layer of a hole transporting material between the anode and the layer of the electroluminescent compound.

15

The hole transporting material can be any of the hole transporting materials used in electroluminescent devices.

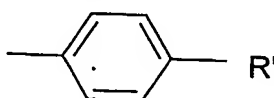
20

The hole transporting material can be an amine complex such as poly (vinylcarbazole), N, N'-diphenyl-N, N'-bis (3-methylphenyl) -1,1' -biphenyl -4,4'-diamine (TPD), an unsubstituted or substituted polymer of an amino substituted aromatic compound, a polyaniline, substituted polyanilines, polythiophenes, substituted polythiophenes, polysilanes etc. Examples of polyanilines are polymers of



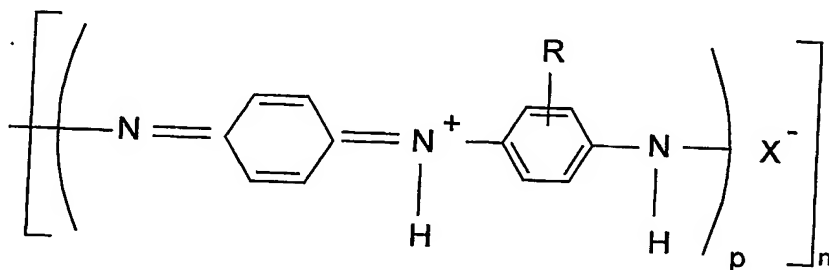
(XIX)

- 5 where R is in the ortho - or meta-position and is hydrogen, C1-18 alkyl, C1-6 alkoxy, amino, chloro, bromo, hydroxy or the group



- 10 where R is alkyl or aryl and R' is hydrogen, C1-6 alkyl or aryl with at least one other monomer of formula I above.

Or the hole transporting material can be a polyaniline, polyanilines which can be used in the present invention have the general formula



(XX)

- 15 where p is from 1 to 10 and n is from 1 to 20, R is as defined above and X is an anion, preferably selected from Cl, Br, SO<sub>4</sub>, BF<sub>4</sub>, PF<sub>6</sub>, H<sub>2</sub>PO<sub>3</sub>, H<sub>2</sub>PO<sub>4</sub>, arylsulphonate, arenedicarboxylate, polystyrenesulphonate, polyacrylate alkylsulphonate, vinylsulphonate, vinylbenzene sulphonate, cellulose sulphonate, camphor sulphonates, cellulose sulphate or a perfluorinated polyanion.
- 20

Examples of arylsulphonates are p-toluenesulphonate, benzenesulphonate, 9,10-anthraquinone-sulphonate and anthracenesulphonate, an example of an arenedicarboxylate is phthalate and an example of arenecarboxylate is benzoate.

- 5 We have found that protonated polymers of the unsubstituted or substituted polymer of an amino substituted aromatic compound such as a polyaniline are difficult to evaporate or cannot be evaporated, however we have surprisingly found that if the unsubstituted or substituted polymer of an amino substituted aromatic compound is deprotonated the it can be easily evaporated i.e. the polymer is evaporable.

10

Preferably evaporable deprotonated polymers of unsubstituted or substituted polymer of an amino substituted aromatic compound are used. The de-protonated unsubstituted or substituted polymer of an amino substituted aromatic compound can be formed by deprotonating the polymer by treatment with an alkali such as ammonium hydroxide or an alkali metal hydroxide such as sodium hydroxide or potassium hydroxide.

15

- The degree of protonation can be controlled by forming a protonated polyaniline and de-protonating. Methods of preparing polyanilines are described in the article by A. G. MacDiarmid and A. F. Epstein, Faraday Discussions, Chem Soc.88 P319 1989.

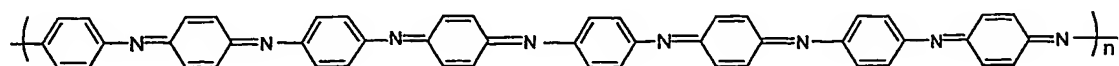
20

The conductivity of the polyaniline is dependant on the degree of protonation with the maximum conductivity being when the degree of protonation is between 40 and 60% e.g. about 50% for example.

25

Preferably the polymer is substantially fully deprotonated

A polyaniline can be formed of octamer units i.e. p is four e.g.



The polyanilines can have conductivities of the order of  $1 \times 10^{-1}$  Siemen  $\text{cm}^{-1}$  or higher.

- 5 The aromatic rings can be unsubstituted or substituted e.g. by a C1 to 20 alkyl group such as ethyl.

- 10 The polyaniline can be a copolymer of aniline and preferred copolymers are the copolymers of aniline with o-anisidine, m-sulphanilic acid or o-aminophenol, or o-toluidine with o-aminophenol, o-ethylaniline, o-phenylene diamine or with amino anthracenes.

- 15 Other polymers of an amino substituted aromatic compound which can be used include substituted or unsubstituted polyaminonaphthalenes, polyaminoanthracenes, polyaminophenanthrenes, etc. and polymers of any other condensed polyaromatic compound. Polyaminoanthracenes and methods of making them are disclosed in US Patent 6,153,726. The aromatic rings can be unsubstituted or substituted e.g. by a group R as defined above.

- 20 Other hole transporting materials are conjugated polymer and the conjugated polymers which can be used can be any of the conjugated polymers disclosed or referred to in US 5807627, PCT/WO90/13148 and PCT/WO92/03490.

- 25 The preferred conjugated polymers are poly (p-phenylenevinylene)-PPV and copolymers including PPV. Other preferred polymers are poly(2,5 dialkoxyphenylene vinylene) such as poly (2-methoxy-5-(2-methoxypentyloxy-1,4-phenylene vinylene), poly(2-methoxypentyloxy)-1,4-phenylenevinylene), poly(2-methoxy-5-(2-dodecyloxy-1,4-phenylenevinylene) and other poly(2,5 dialkoxyphenylenevinylenes) with at least one of the alkoxy groups being a long chain solubilising alkoxy group,



poly fluorenes and oligofluorenes, polyphenylenes and oligophenylenes, polyanthracenes and oligo anthracenes, ploythiophenes and oligothiophenes.

5 In PPV the phenylene ring may optionally carry one or more substituents e.g. each independently selected from alkyl, preferably methyl, alkoxy, preferably methoxy or ethoxy.

10 Any poly(arylenevinylene) including substituted derivatives thereof can be used and the phenylene ring in poly(p-phenylenevinylene) may be replaced by a fused ring system such as anthracene or naphthylene ring and the number of vinylene groups in each polyphenylenevinylene moiety can be increased e.g. up to 7 or higher.

15 The conjugated polymers can be made by the methods disclosed in US 5807627, PCT/WO90/13148 and PCT/WO92/03490.

The thickness of the hole transporting layer is preferably 20nm to 200nm.

20 The polymers of an amino substituted aromatic compound such as polyanilines referred to above can also be used as buffer layers with or in conjunction with other hole transporting materials.

25 The structural formulae of some other hole transporting materials are shown in Figures 4, 5, 6, 7 and 8 of the drawings, where  $R_1$ ,  $R_2$  and  $R_3$  can be the same or different and are selected from hydrogen, and substituted and unsubstituted hydrocarbonyl groups such as substituted and unsubstituted aliphatic groups, substituted and unsubstituted aromatic, heterocyclic and polycyclic ring structures, fluorocarbons such as trifluoromethyl groups, halogens such as fluorine or thiophenyl groups;  $R_1$ ,  $R_2$  and  $R_3$  can also form substituted and unsubstituted fused aromatic, heterocyclic and polycyclic ring structures and can be copolymerisable with a monomer e.g.  
30 styrene. X is Se, S or O, Y can be hydrogen, substituted or unsubstituted hydrocarbonyl

groups, such as substituted and unsubstituted aromatic, heterocyclic and polycyclic ring structures, fluorine, fluorocarbons such as trifluoromethyl groups, halogens such as fluorine or thiophenyl groups or nitrile.

5 Examples of  $R_1$  and/or  $R_2$  and/or  $R_3$  include aliphatic, aromatic and heterocyclic alkoxy, aryloxy and carboxy groups, substituted and substituted phenyl, fluorophenyl, biphenyl, phenanthrene, anthracene, naphthyl and fluorene groups alkyl groups such as t-butyl, heterocyclic groups such as carbazole.

10 Optionally there is a layer of an electron injecting material between the anode and the electroluminescent material layer, the electron injecting material is a material which will transport electrons when an electric current is passed through electron injecting materials include a metal complex such as a metal quinolate e.g. an aluminium quinolate, lithium quinolate, a cyano anthracene such as 9,10 dicyano anthracene, 15 cyano substituted aromatic compounds, tetracyanoquinodimethane a polystyrene sulphonate or a compound with the structural formulae shown in figures 2 or 3 of the drawings in which the phenyl rings can be substituted with substituents R as defined above.

20 The cathode is preferably a transparent substrate such as a conductive glass or plastic material which acts as the anode, preferred substrates are conductive glasses such as indium tin oxide coated glass, but any glass which is conductive or has a conductive layer such as a metal or conductive polymer can be used. Conductive polymers and conductive polymer coated glass or plastics materials can also be used as the substrate.

25 The anode is preferably a low work function metal e.g. aluminium, calcium, lithium, silver/magnesium alloys, rare earth metal alloys etc., aluminium is a preferred metal. A metal fluoride such as an alkali metal, rare earth metal or their alloys can be used as the second electrode for example by having a metal fluoride layer formed on a

- 16 -

metal.

# Claims

1. An electroluminescent compound of formula  $M(L)_n$  and  $MO(L)_{n-2}$  where M is a metal in a valency state n of greater than 3 and L is an organic ligand, the ligands L can be the same or different e.g.  $M(L_1)(L_2)(L_3)(L_4)\dots$  or  $MO(L_1)(L_2)\dots$

2. An electroluminescent compound as claimed in claim 1 in which the metal M is a titanium, zirconium or hafnium in the four valency state or vanadium, niobium or tantalum in the five valency state.

3. An electroluminescent compound as claimed in claim 1 of formula of fig. 1.

4. An electroluminescent compound as claimed in any one of claims 1 to 3 in which the ligands L are the same or different.

5. An electroluminescent compound as claimed in claim 1 of formula  $M(L_1)(L_2)(L_3)(L_4)$  or  $MO(L_1)(L_2)$  where the groups  $(L_1)$ ,  $(L_2)$ ,  $(L_3)$  and  $(L_4)$  are the same or different where M is zirconium, hafnium or titanium in the four valency state.

6. An electroluminescent compound as claimed in claim 1 of formula  $M(L_1)(L_2)(L_3)(L_4)(L_5)$  or  $MO(L_1)(L_2)(L_3)$  where the groups  $(L_1)$ ,  $(L_2)$ ,  $(L_3)$  and  $(L_4)$   $(L_5)$  are the same or different where M is vanadium, niobium or tantalum in the five valency state.

7. An electroluminescent compound as claimed in any one of the preceding claims in which the ligands L are selected from ligands (I) to (XVIII) herein.

8. An electroluminescent compound as claimed in any one of the preceding claims in which the ligands L are selected from quinolate, porphoryn, pyrazalones, and  $\beta$  diketones such as dibenzoyl methane.

9. An electroluminescent composition which comprises an electroluminescent compound as claimed in claim 1 or claim 2 and a dopant.
- 5 10. An electroluminescent composition as claimed in claim 9 in which the dopant is selected from diphenylacridine, coumarins, perylene, quinolates, porphoryin, porphines, pyrazalones and their derivatives.
- 10 11. An electroluminescent composition as claimed in claim 9 in which the dopant is selected from compounds of formula (A), (B) and (C) and compounds of figures 9 to 13 of the drawings.
- 15 12. An electroluminescent device which comprises (i) a first electrode, (ii) a layer of electroluminescent compound or composition as claimed in any one of claims 1 to 11 and (iii) a second electrode.
- 20 13. An electroluminescent device as claimed in claim 12 in which there is a layer of a hole transmitting material between the first electrode and the electroluminescent layer.
- 25 14. An electroluminescent device as claimed in claim 13 in which the hole transmitting material is an aromatic amine complex.
- 30 15. An electroluminescent device as claimed in claim 12 in which the hole transmitting material is polyaromatic amine complex.
16. An electroluminescent device as claimed in claim 13 in which the hole transmitting material is a film of a polymer selected from poly(vinylcarbazole), N,N'-diphenyl-N,N'-bis (3-methylphenyl) -1,1' -biphenyl -4,4'-diamine (TPD), polyaniline, substituted polyanilines, polythiophenes, substituted polythiophenes, polysilanes and substituted polysilanes.

17. An electroluminescent device as claimed in claim 13 in which the hole transmitting material is a film of a compound of formula (XIX) or (XXV) herein or as in figures 4 to 8 of the drawings.
- 5 18. An electroluminescent device as claimed in claim 14 in which the hole transmitting material is a copolymer of aniline, a copolymer of aniline with o-anisidine, m-sulphanilic acid or o-aminophenol, or o-toluidine with o-aminophenol, o-ethylaniline, o-phenylene diamine or with an amino anthracene.
- 10 19. An electroluminescent device as claimed in claim 15 in which the hole transmitting material is a conjugated polymer.
- 15 20. An electroluminescent device as claimed in claim 18 in which the conjugated polymer is selected from poly (p-phenylenevinylene)-PPV and copolymers including PPV, poly(2,5 dialkoxyphenylene vinylene), poly (2-methoxy-5-(2-methoxypentyloxy-1,4-phenylene vinylene), poly(2-methoxypentyloxy)-1,4-phenylenevinylene), poly(2-methoxy-5-(2-dodecyloxy-1,4-phenylenevinylene) and other poly(2,5 dialkoxyphenylenevinylenes) with at least one of the alkoxy groups being a long chain solubilising alkoxy group, poly fluorenes and oligofluorenes, polyphenylenes and oligophenylenes, polyanthracenes and oligo anthracenes, ploythiophenes and oligothiophenes.
- 20 21. An electroluminescent device as claimed in any one of claims 12 to 20 in which the electroluminescent compound is mixed with the hole transmitting material.
- 25 22. An electroluminescent device as claimed in any one of claims 14 to 20 in which there is a layer of an electron transmitting material between the cathode and the electroluminescent compound layer.

23. An electroluminescent device as claimed in claim 22 in which the electron transmitting material is a metal quinolate.

24. An electroluminescent device as claimed in claim 23 in which the metal quinolate is an aluminium quinolate or lithium quinolate

25. An electroluminescent device as claimed in claim 24 in which the electron transmitting material is of formula  $Mx(DBM)_n$  where Mx is a metal and DBM is dibenzoyl methane and n is the valency of Mx.

10

26. An electroluminescent device as claimed in claim 22 in which the electron transmitting material is a cyano anthracene such as 9,10 dicyano anthracene, a polystyrene sulphonate or a compound of formulae shown in figure 2 or 3 of the drawings.

15

27. An electroluminescent device as claimed in any one of claims 22 to 24 in which the electron transmitting material is mixed with the electroluminescent compound.

20

28. An electroluminescent device as claimed in any one of the claims 12 to 25 in which the first electrode is a transparent electricity conducting glass electrode.

29. An electroluminescent device as claimed in any one of the claims 12 to 26 in which the second electrode is selected from aluminium, calcium, lithium, magnesium and alloys thereof and silver/magnesium alloys.

25

Abstract

An electroluminescent compound is a organometallic complex in which the metal is titanium, zirconium, hafnium, vanadium, niobium or tantulum.



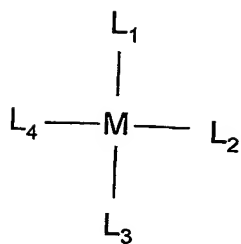


Fig. 1a

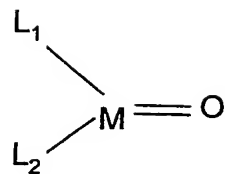


Fig. 1b

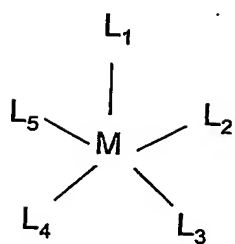


Fig. 1c

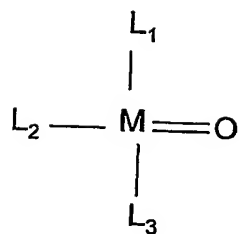
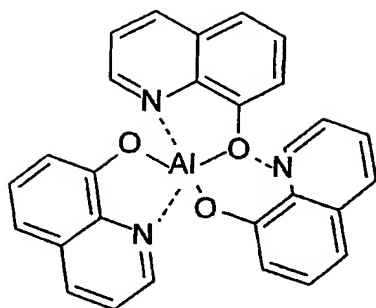
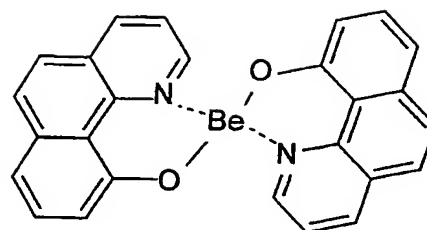


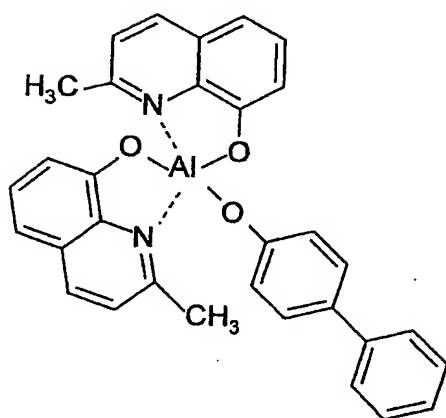
Fig. 1d



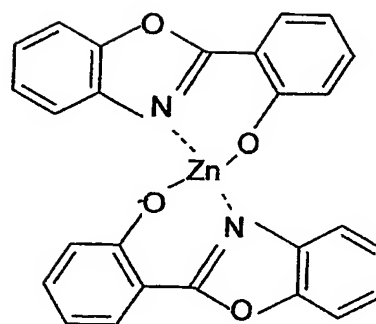
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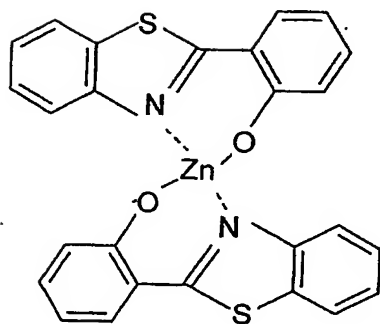
Bebq



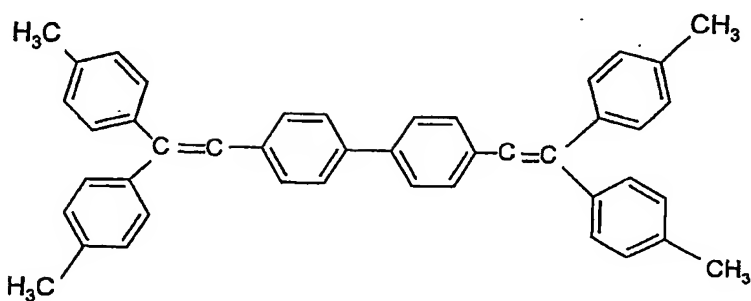
BAiq1



ZnPBO

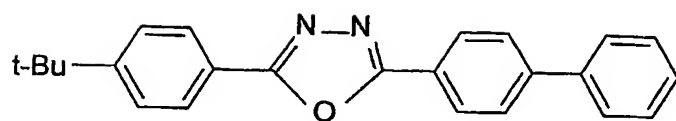


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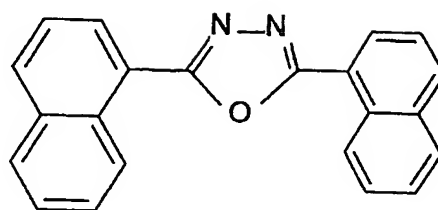


DTVb1

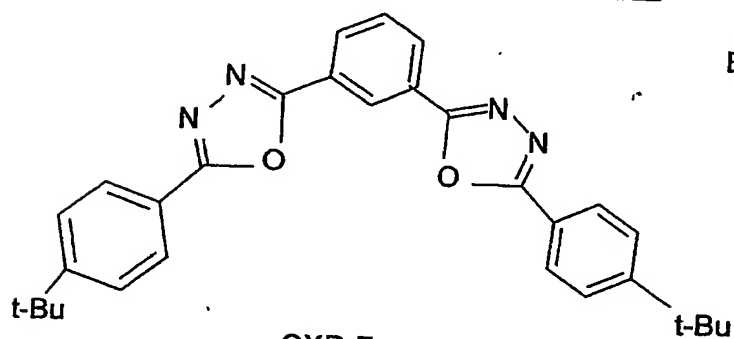
Fig. 2



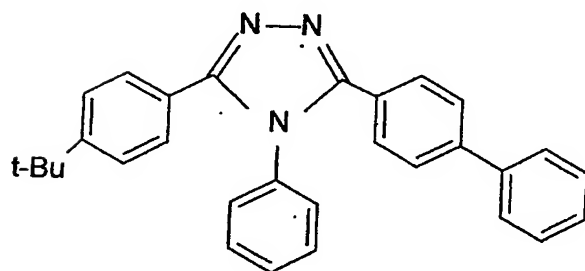
t-Bu-PBD



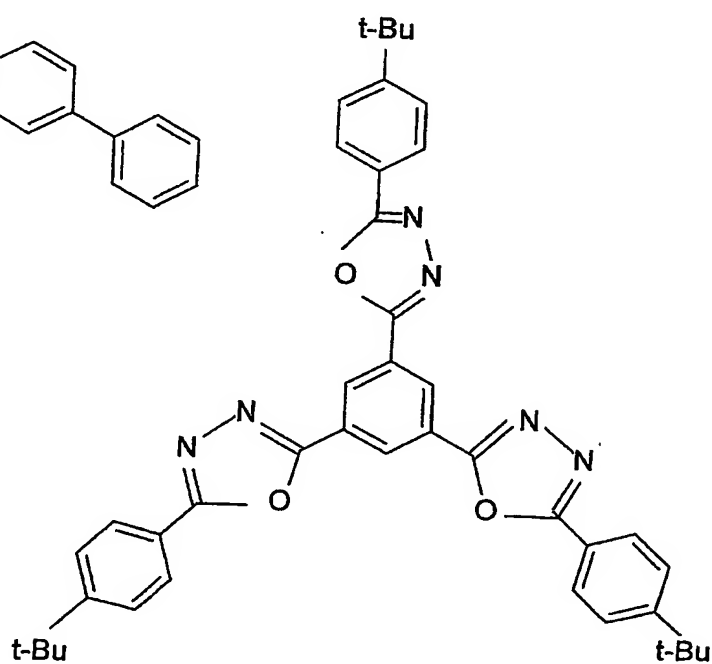
BND



OXD-7



TAZ



OXD-Star

Fig. 3

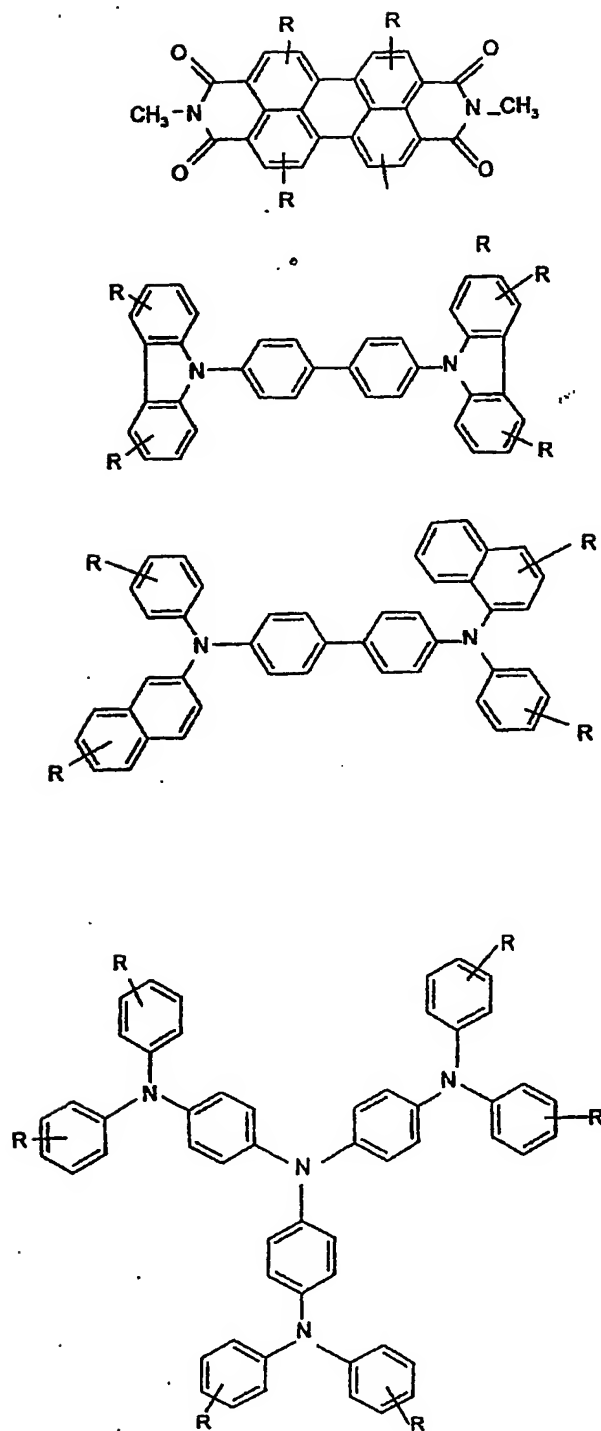


Fig. 4

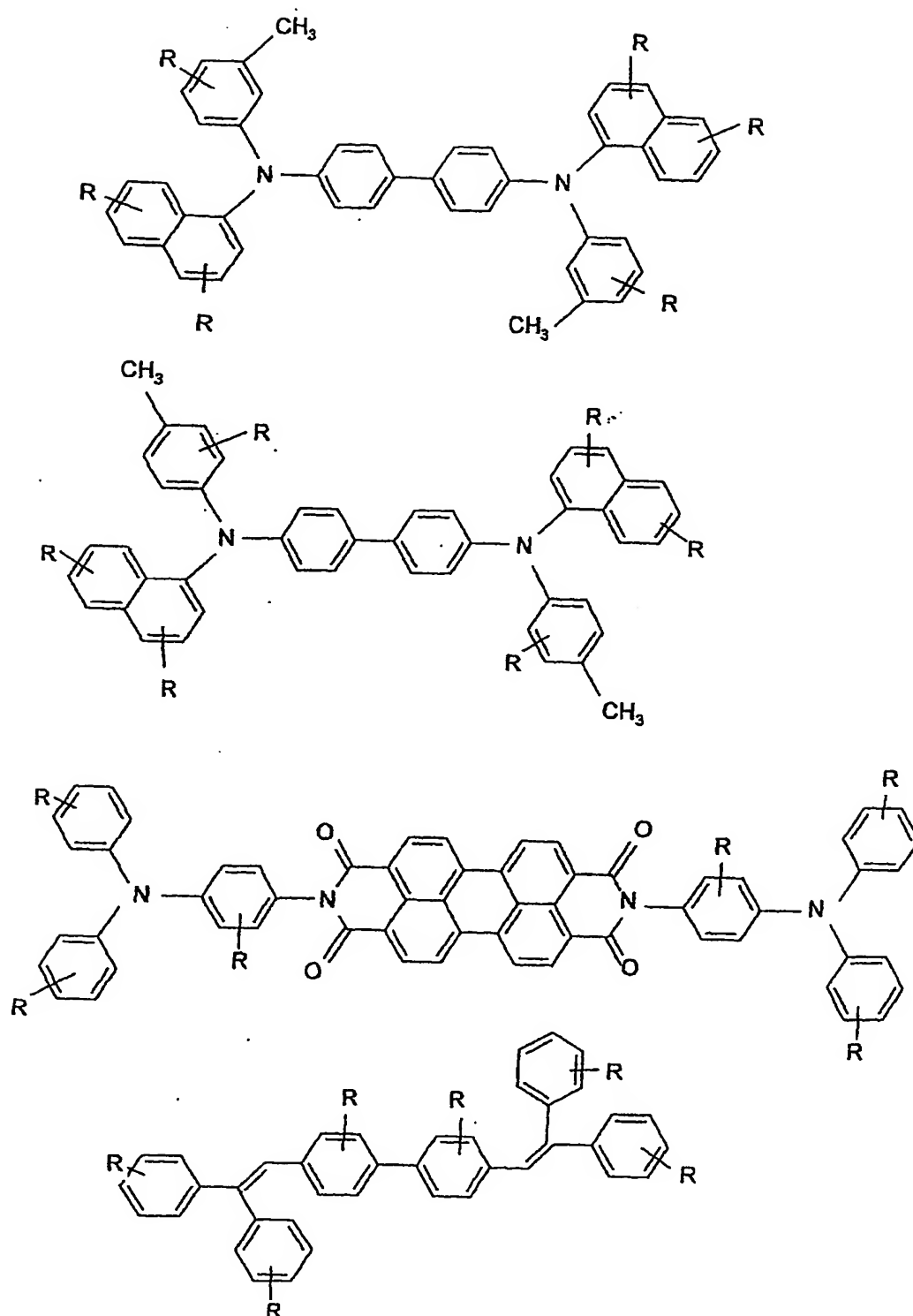


Fig. 5

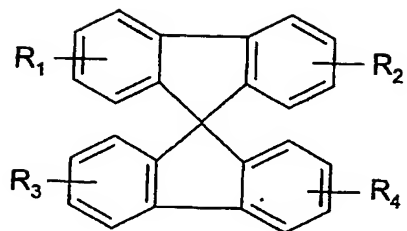


Fig. 14a

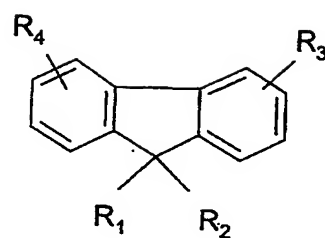
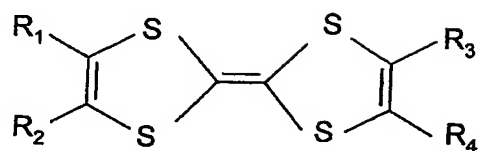


Fig. 14b



or

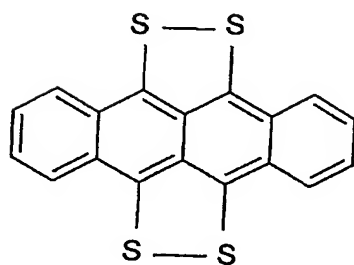
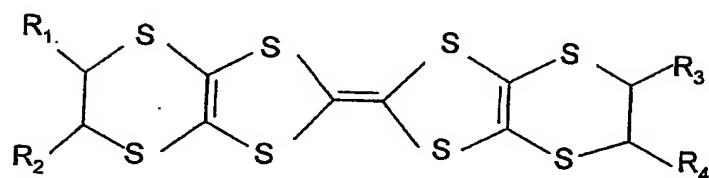


Fig. 6

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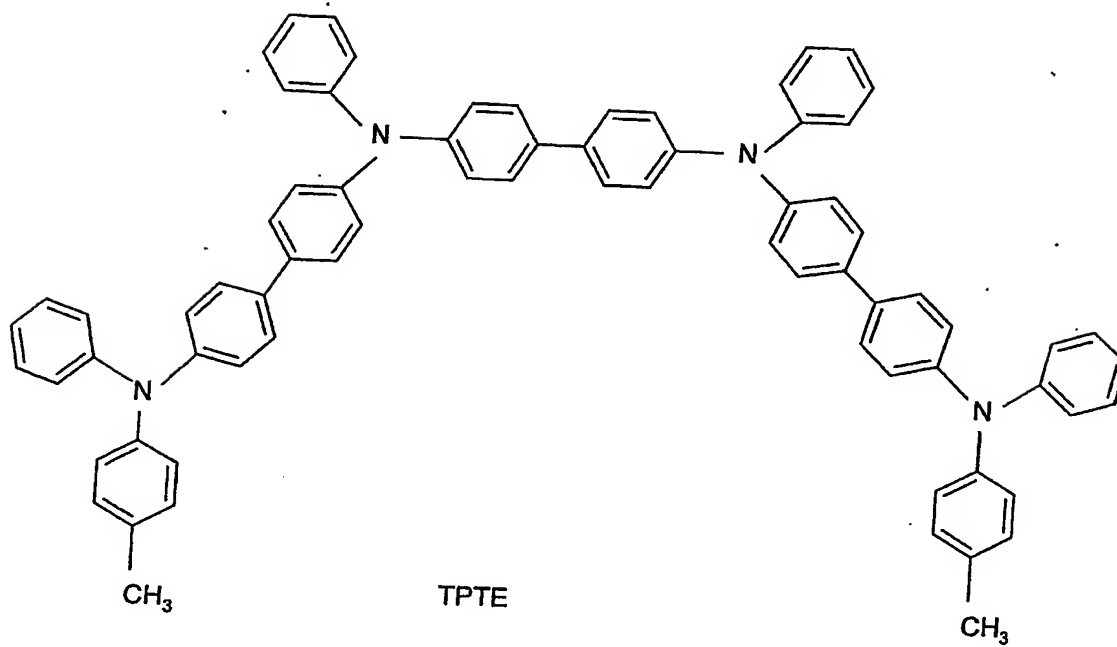
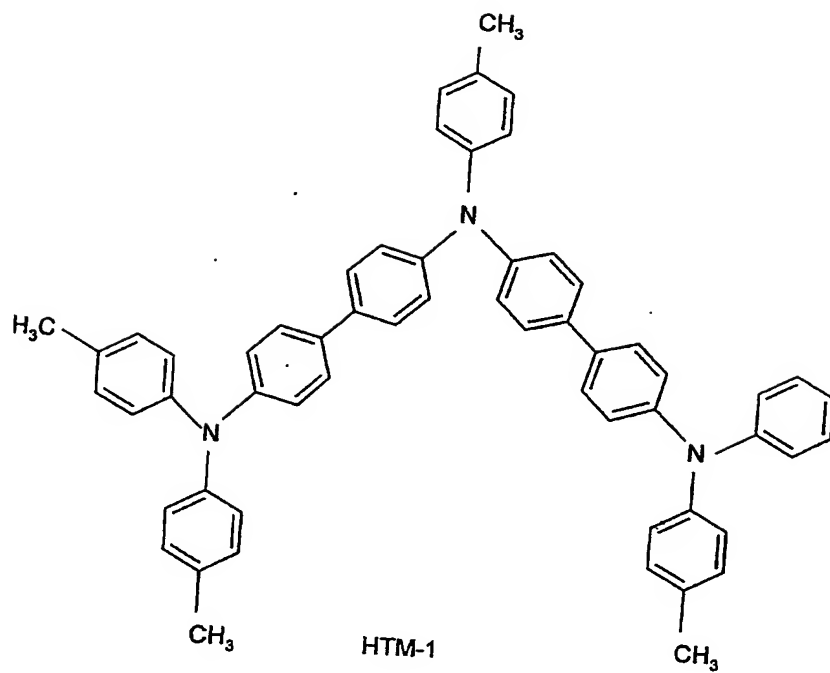
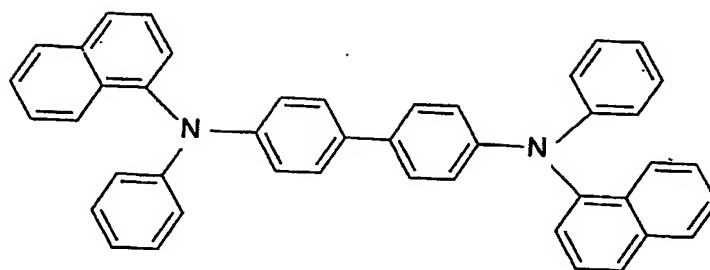
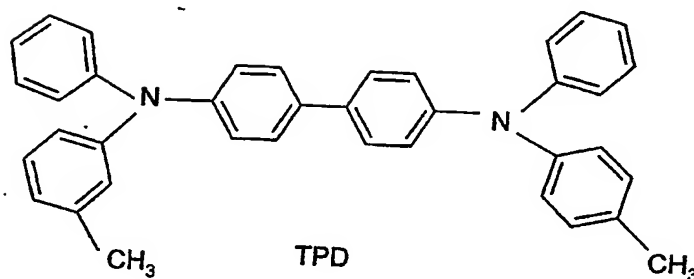


Fig. 7

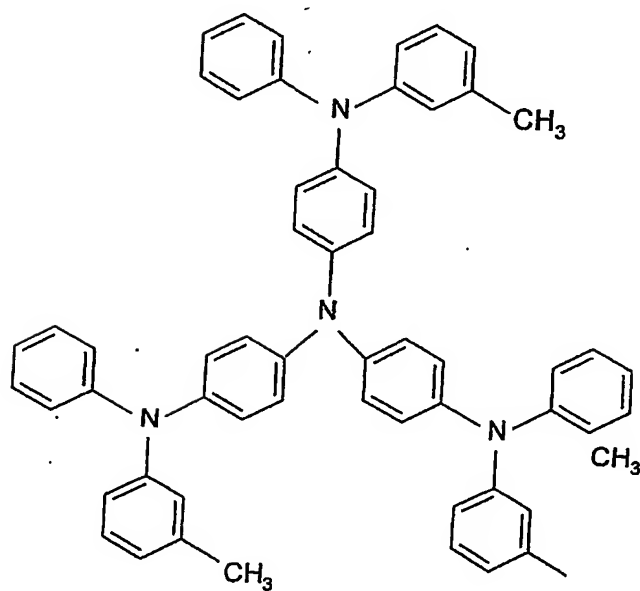
8/13



$\alpha$ -NPB



TPD



mTADATA

Fig. 8



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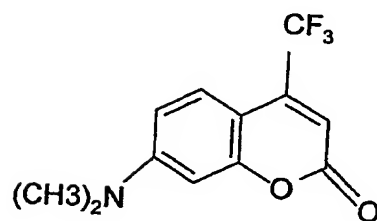
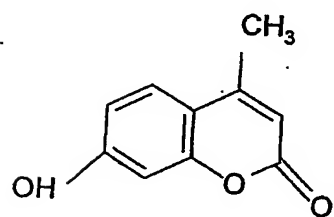
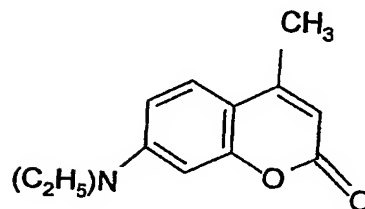
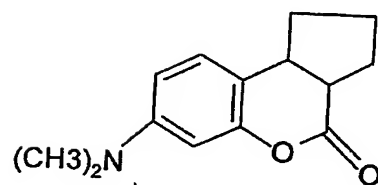
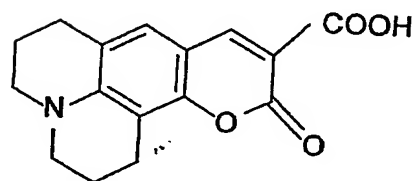
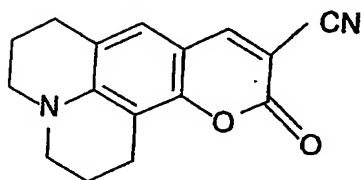
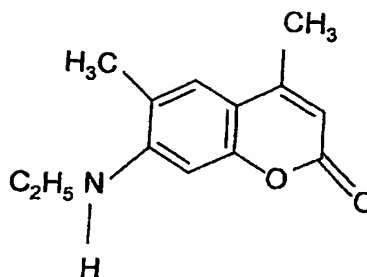
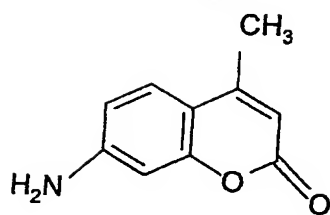


Fig. 17

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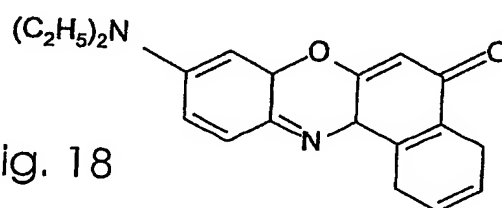
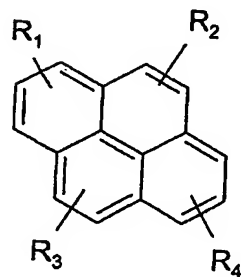
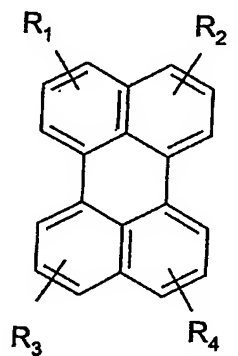
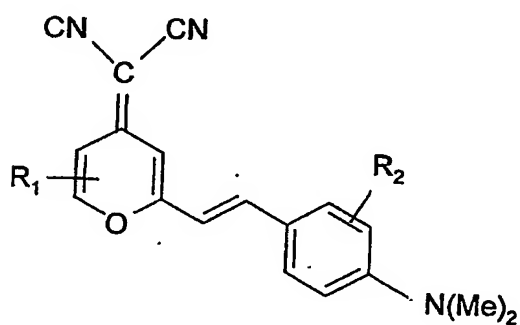
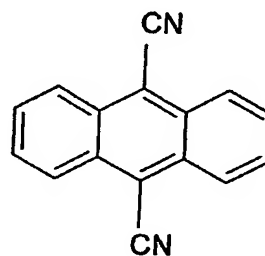
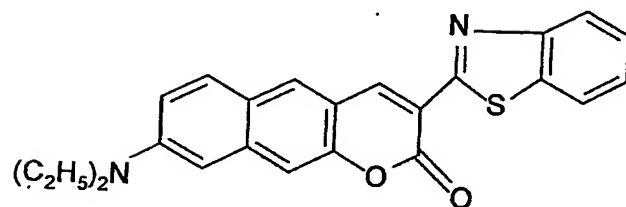
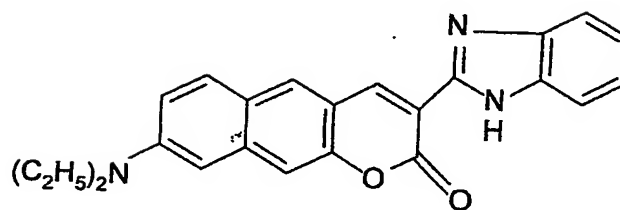
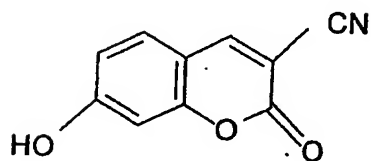
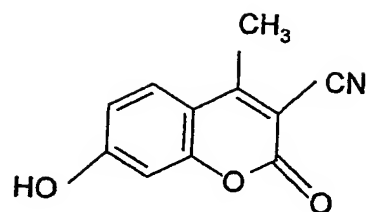
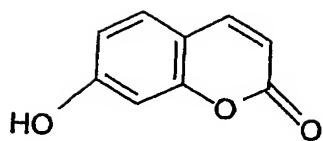


Fig. 18

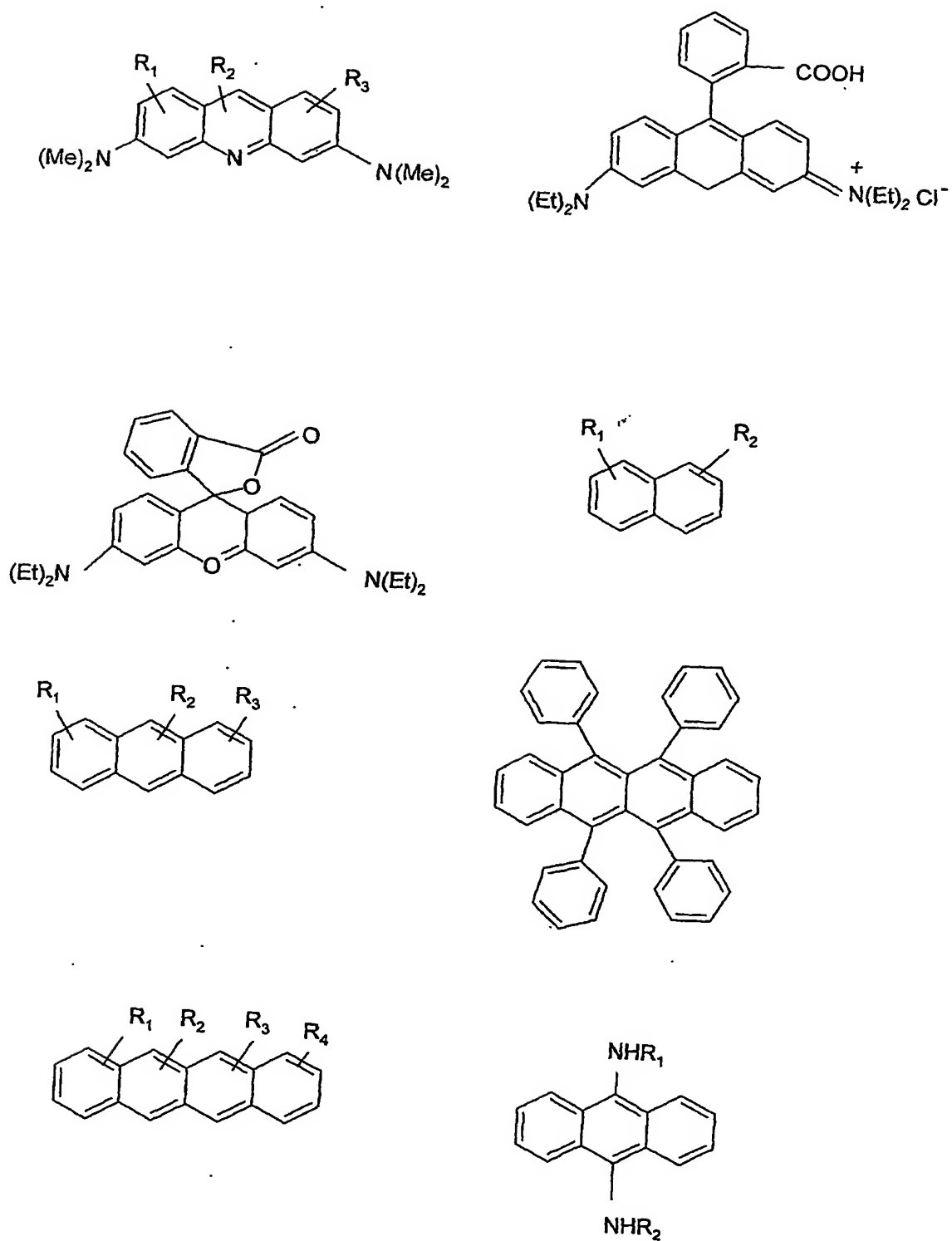


Fig. 19

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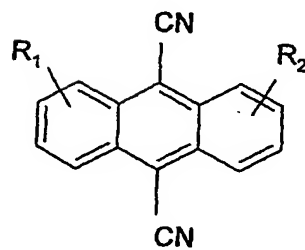
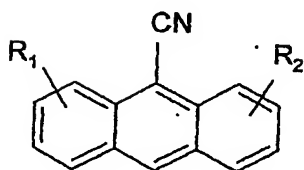
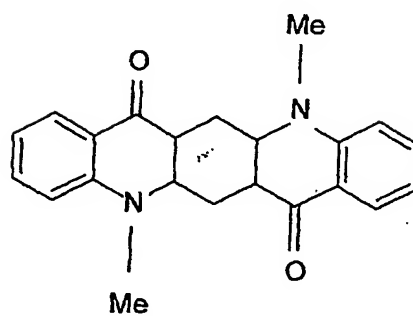
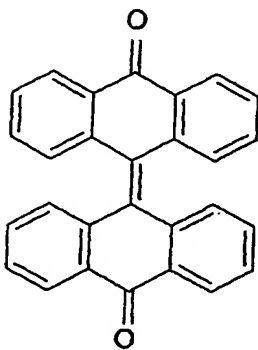
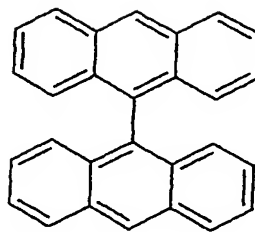
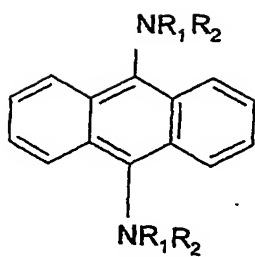


Fig. 20

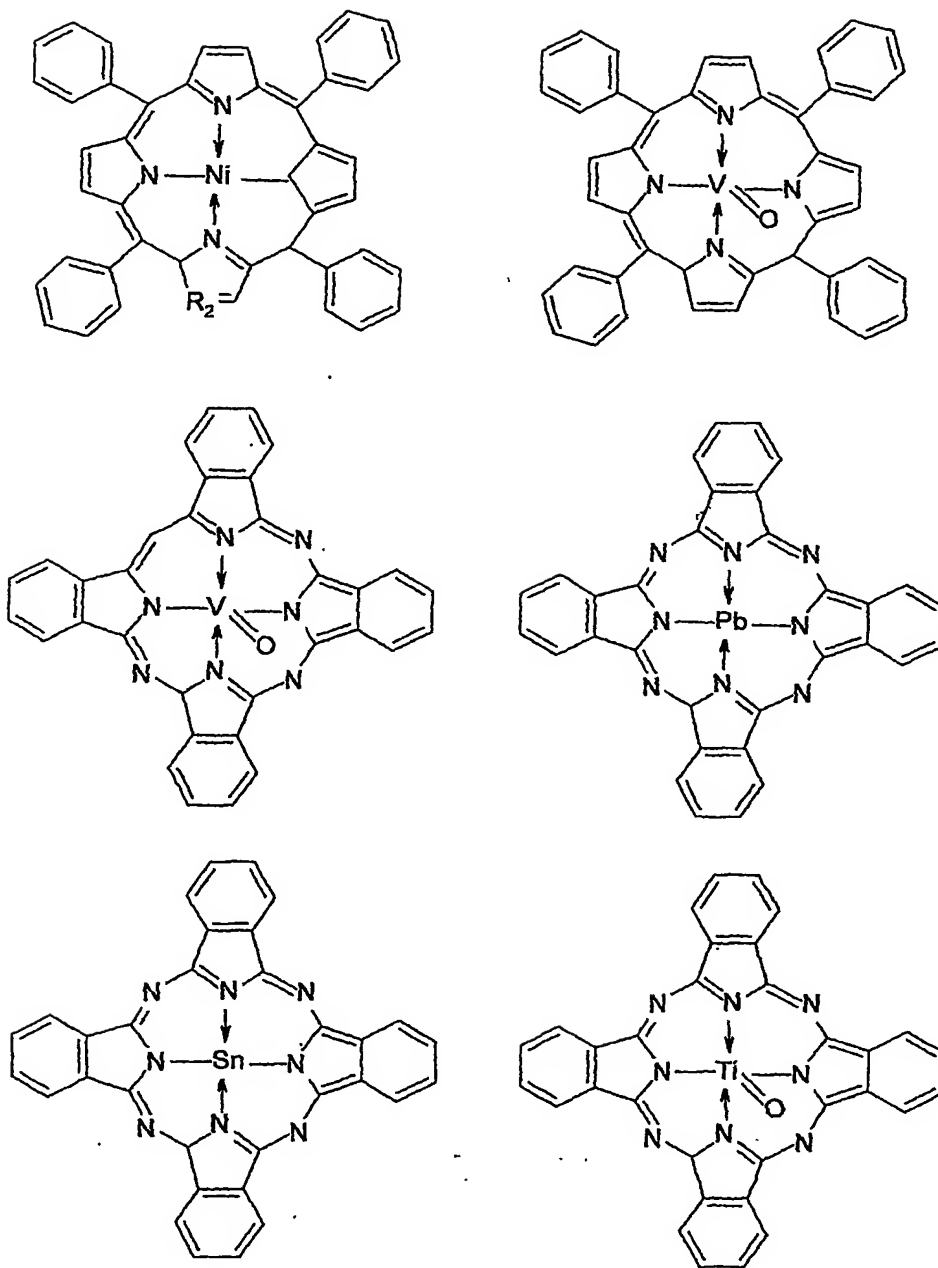


Fig. 21

PCT Application  
**GB0305573**



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